

## Measurements With a Superconducting Magnet Spectrometer

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A recently constructed superconducting magnet spectrometer will measure the composition and spectra of cosmic rays over 3 orders of magnitude in energy from a few billion electron volts to approximately 1 tera-electron volt. This measurement will overlap the prior data below 100 billion electron volts and extend upward to the high-energy data measured by the Japanese/American Cooperative Emulsion Experiment. (This experiment is part of a continuing collaborative effort with Japanese and American universities.) Additionally, the magnet spectrometer will analyze secondary charged particles emerging from the cosmic-ray interactions with targets in the instrument in an energy regime where a nuclear phase change in matter is predicted to occur. With a magnetic field of 1.2 Tesla and a position resolution of less than 2 micrometers in the emulsion chamber, the primary spectra of heavy nuclei can be measured to approximately 1 tera-electron volt, and nuclear interactions can be studied up to approximately 10 tera-electron volts.

The magnet spectrometer target contains lead plates and passive detectors, consisting of thin sheets of CR39 track detectors, emulsion plates, and spacers designed to measure the

momenta of the cosmic-ray primaries to approximately 1 tera-electron volt. Also, a systematic study of the interaction characteristics of energetic cosmic-ray nuclei permits a re-examination of the "standard" nuclear interaction model, since occasional unexplained "exotic" events have been observed at high energies. Those events have an excess ("Chirons") or deficiency ("Centauros") of neutral particles compared to the charged particles produced in the interactions. With emulsion chambers in a balloon-borne superconducting magnet, more definitive measurements of the charged secondary particles produced in nuclear interactions will be made in order to test new theoretical interaction models and compare the data to the standard models currently in use.

The subject experiments are expected to bridge the existing low- and high-energy spectral data for the cosmic-ray elements carbon through iron, and allow data from several previous experiments to be cross-calibrated. This would extend the confirmed cosmic-ray energy spectra over many decades in energy, enabling a better comparison with predictions of supernova remnant acceleration models of cosmic rays.

The balloon flight instrument contains two 50- (width) by 50- (length) by 40-centimeter (height) emulsion chambers that include two special target sections (fig. 16). One target section is a stack of magnet-interaction chambers that consist of lead and emulsion plates, as well as CR39 track detectors separated by low-density spacers. The other target section contains a "beam tracker" of

CR39 plates with spacers on top of a single magnet-interaction target module. Both stacks have an "ionization calorimeter" on the bottom that provides data on high-energy, primary cosmic rays above 500 billion electron volts by measuring the electromagnetic cascade energy of each event. The beam tracker determines the charges and momenta of the primary cosmic-ray nuclei by the CR39 etch-pit method and track curvature, respectively. The magnet-interaction section detects interactions in lead targets and enables measurements with emulsion plates of production angles and momenta of most of the secondary charged particles. The ionization calorimeter has x-ray films and emulsion plates with 8 radiation lengths of lead to generate electromagnetic (gamma-ray/electron) showers, which will provide individual cascade/shower energy measurements.

The balloon-borne magnet spectrometer experiment is shown schematically in figure 16. The solenoid magnet has an open bore of 85 (depth) by 180 centimeters (length). The magnet structure has a low mass thickness, reducing the cosmic-ray event loss due to nuclear fragmentation. It operates at a maximum field strength of 1.2 Tesla in the persistent current mode with 520 amperes. The emulsion chamber boxes are supported by a shaft arrangement that penetrates the magnet's open bore (fig. 17) and is fastened to horizontal support bars on the gondola (shown in figs. 16 and 17). The magnet alone weighs 450 kilograms with a 10-day liquid-helium supply (250-liter cryostat).

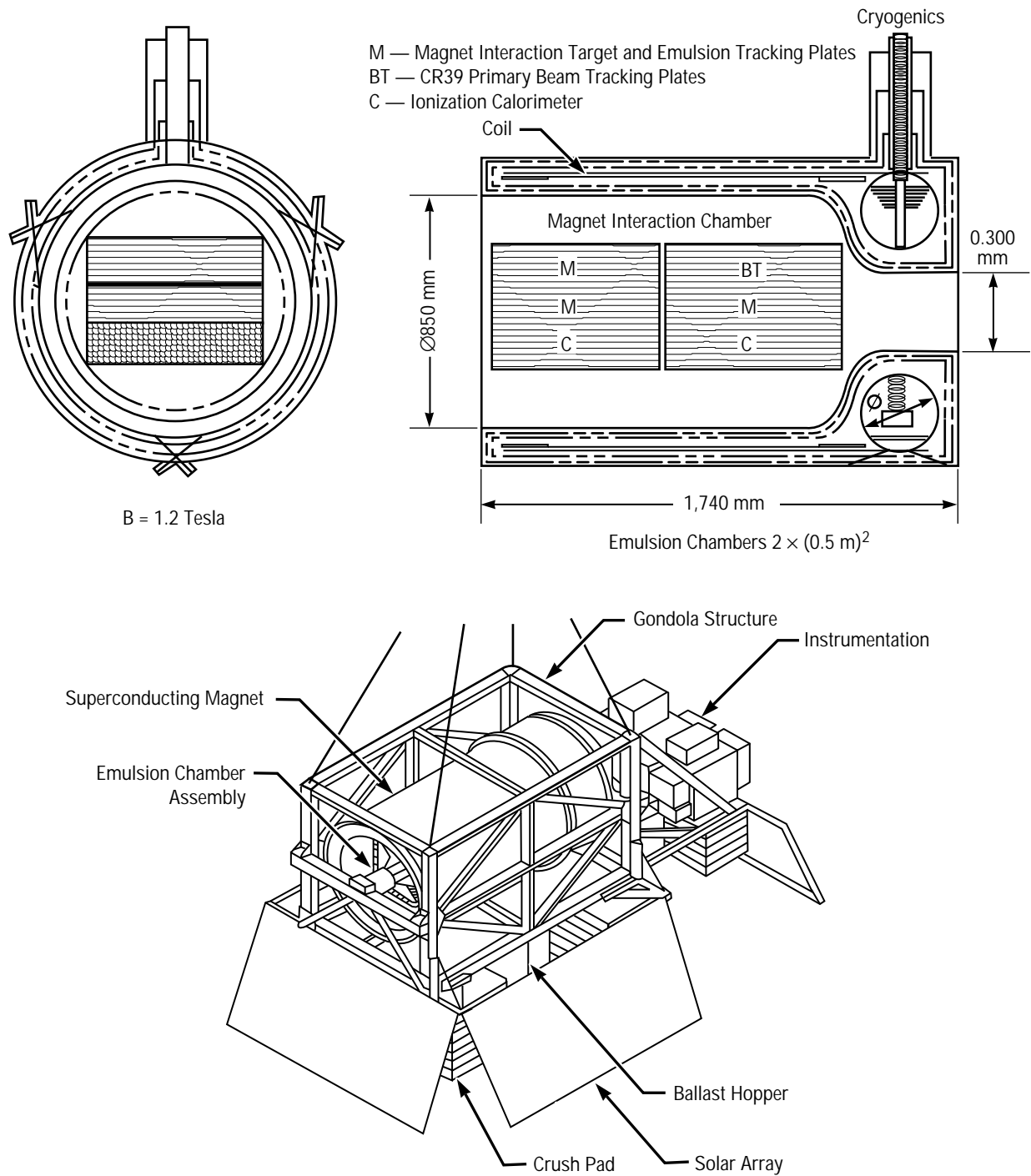


FIGURE 16.—The configuration of the gondola, superconducting magnet, and the emulsion chambers for a Japanese/American Cooperative Emulsion Experiment flight, the Super-JACEE. The weight of the scientific apparatus is 1,400 kilograms.

The magnet system with gondola, emulsion chambers, flight monitor and control system, and ground-support equipment has been assembled at MSFC. The first test-flight experiment on a high-altitude balloon was successfully conducted from Fort Sumner, New Mexico, on September 27, 1995, gathering data for a period of approximately 20 hours. At least one long-duration balloon flight (of approximately 10 days) is planned, followed by 3 years of data analysis.

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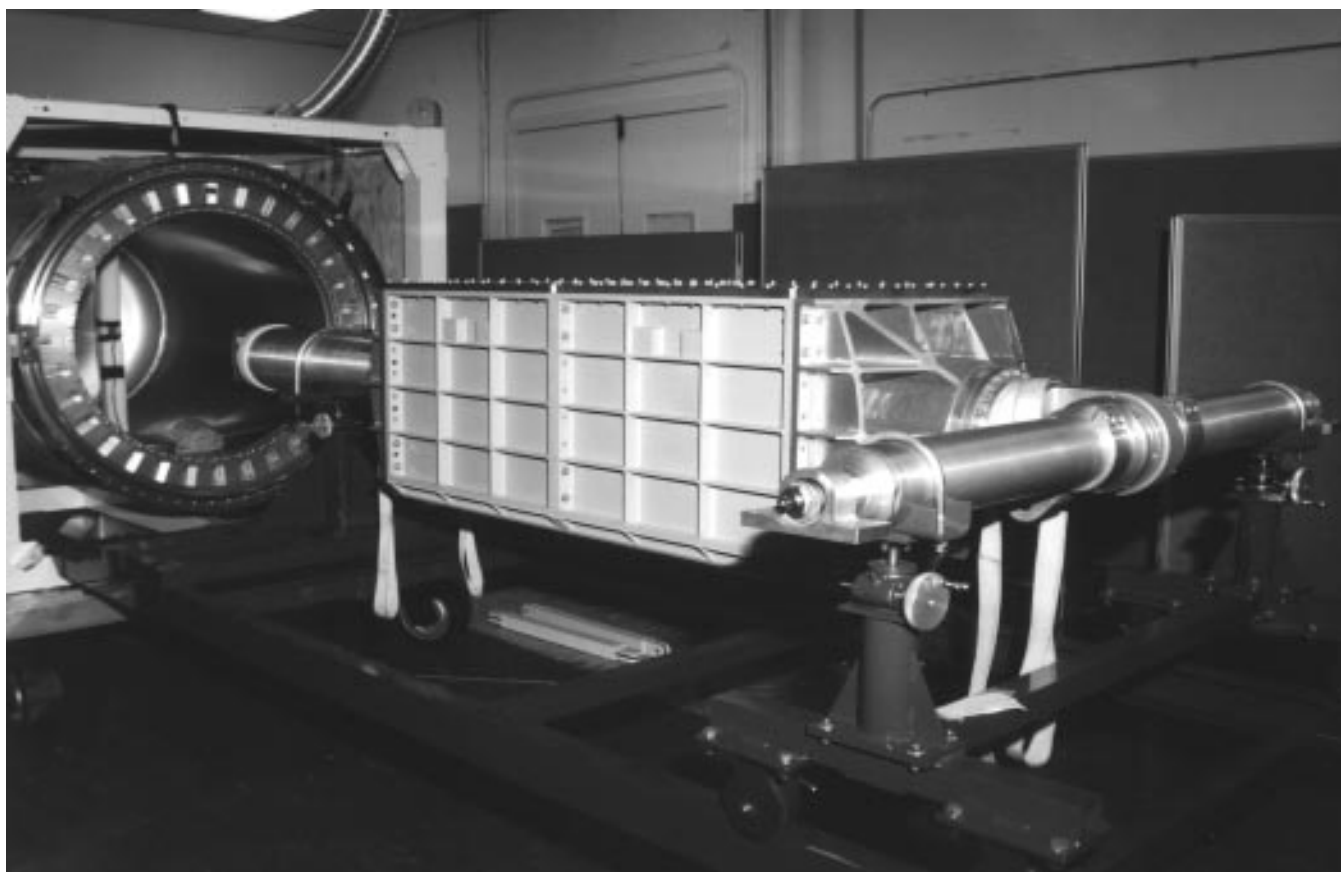


FIGURE 17.—Emulsion chamber assembly ready for insertion into the open bore of the superconducting magnet.